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Some Aids to the Design of Suberkrub Otterboards

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Some Aids to the Design of Suberkrub Otterboards

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Introduction

The aim of this pamphlet is to give the otterboard designer some insight into the requirements of the design and manufacture of Suberkrub otterboards and to provide practical help in choosing the principal dimensions.

Suberkrub otterboards are used in many parts of the world mainly for mid-water or near seabed fishing. They have a characteristic curved shape (Fig. 1) and a height which is roughly twice the breadth. These two features are responsible for the very high hydrodynamic efficiency; a Suberkrub otterboard has a much greater spreading power than a traditional flat trawl board of the same area. The warp is attached to a towing point positioned about half way up the otterboard and the twin sweeps are usually attached to single backstrops which in turn are shackled to the top plate and keel plate. These otterboards are normally rigged to tow in a nearly upright position. Details of their rigging and operation are given by Ferro (1980).

The Design Procedure

What size of otterboard is required?

The size of Suberkrub board chosen for a particular net has a significant effect on the performance of the gear as a whole. Most pelagic-type four-panel nets are designed to have roughly square mouths — that is, the headline and footrope are approximately the same length as the sidelines. If an incorrect board size is used, the net mouth will not be square and the net itself may be distorted with areas of slack or strained netting.

Therefore the size of otterboard must be chosen to suit the net which is to be spread. The horsepower and tonnage of the towing vessel are not so important.

The following simple formulae were devised by Ferro (1981a) to calculate the right area and weight of otterboard for a given net made of nylon:

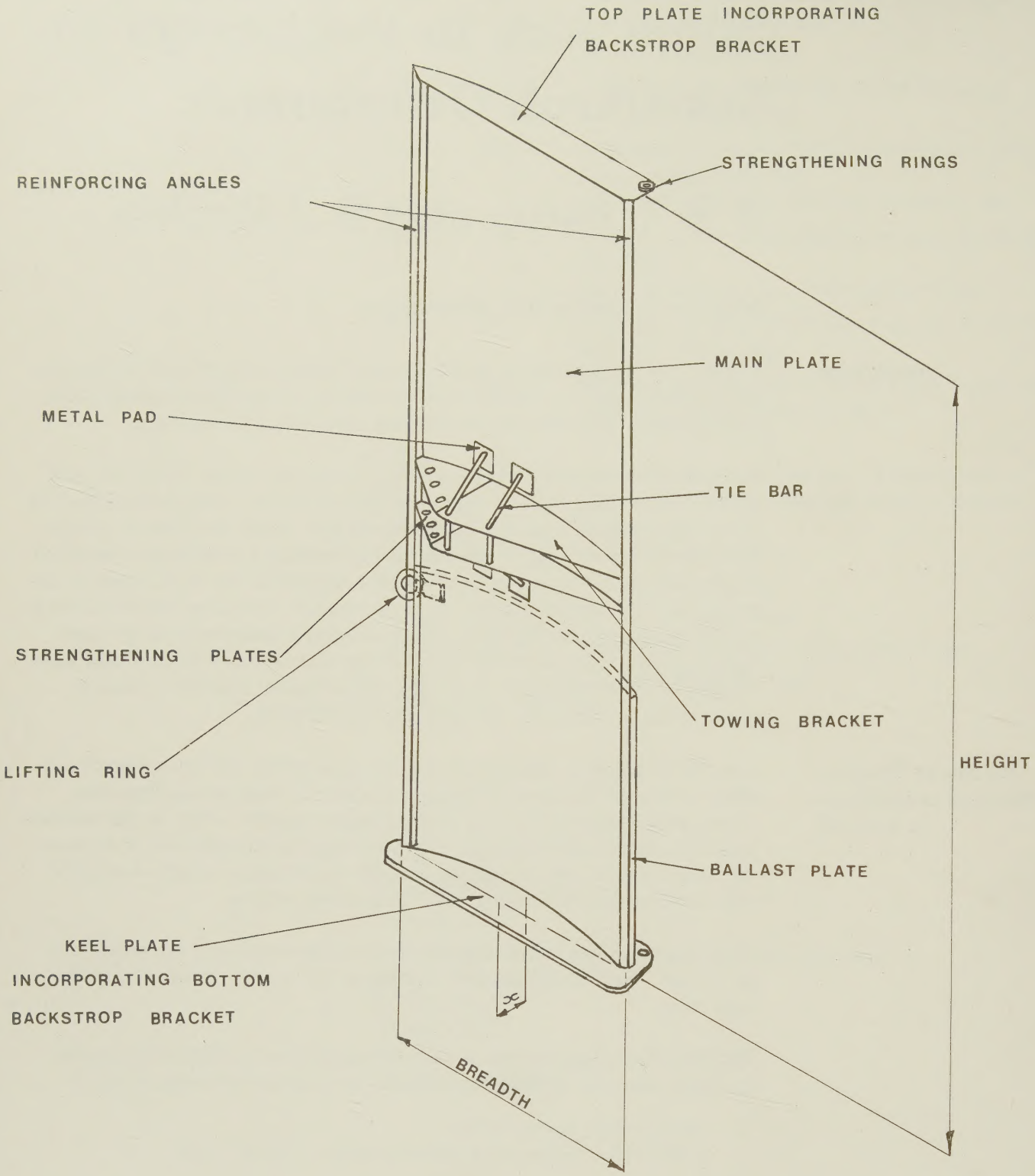
board area in square metres
= (0.0152 x twine area of trawl in square metres) + 1.23

board weight in kg
= 75 x board area in square metres $^{1.5}$

The twine area of the trawl in square metres may be calculated using the method described by Ferro (1981b).

These formulae apply only to nylon four-panel nets having a twine area between 25 and 350 square metres. This range of nets is used on vessels from approximately 150 to 2000 hp.

Figures 2 and 3 may be used to read off the board area and weight directly.



$$\% \text{ CAMBER} = \frac{100\ x}{\text{BREADTH}}$$

Figure 1 Sketch of Suberkrub otterboard showing main components.

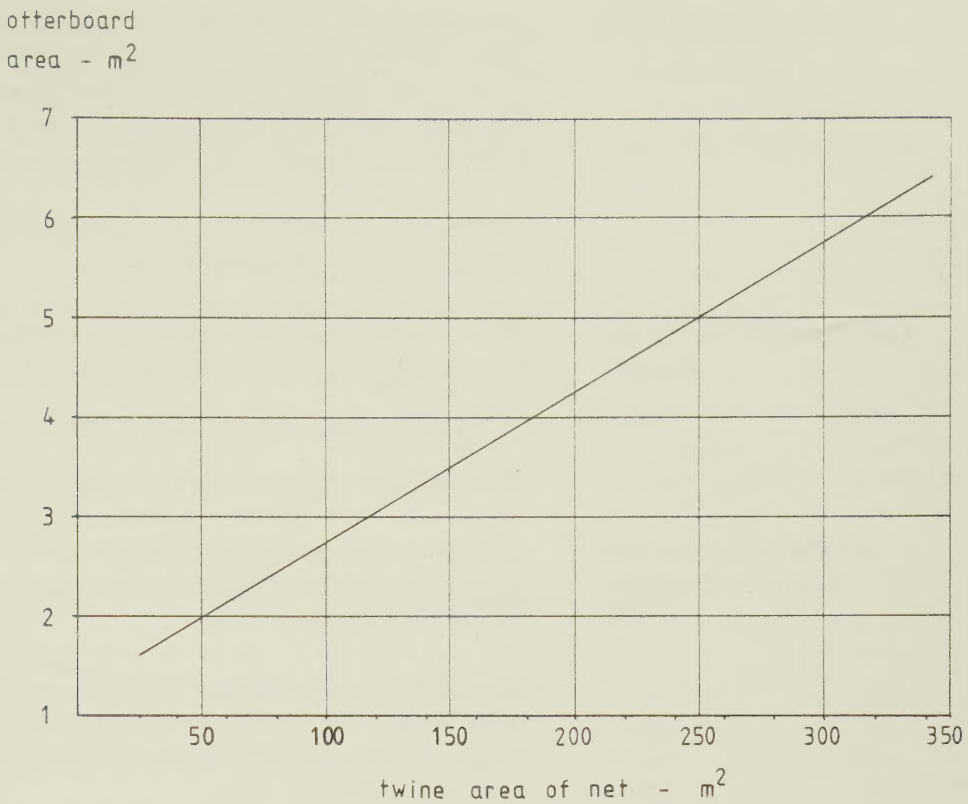


Figure 2 Determination of otterboard area in square metres from nominal twine area in square metres of a nylon four-panel pelagic net. (Applicable to nylon nets of twine area between 25 and 350 m^2.)

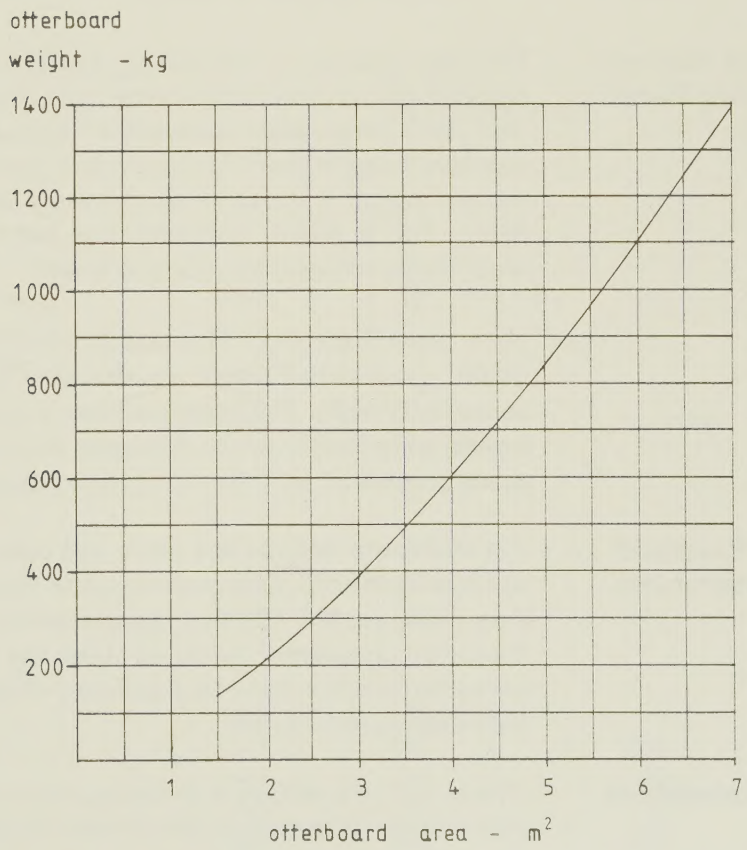


Figure 3 Determination of otterboard weight in kilogrammes from otterboard area in square metres. (Applicable to Suberkrub boards up to 7 m^2.)

Choice of Aspect Ratio

The aspect ratio is the ratio of the height to the breadth (see Figure 1) and it influences the spreading efficiency of the otterboard. In general a higher aspect ratio means a greater hydrodynamic efficiency although there are practical limitations. A very high narrow otterboard might be more difficult to handle on shooting, and takes up more space when stowed.

An aspect ratio of 2.25 is a good compromise, although aspect ratios between 2 and 2.5 are common.

Calculation of Height and Breadth

When the area has been obtained, and assuming an aspect ratio of 2.25, the board height may be calculated from the formula:

$$\text{height in metres} = \sqrt{(2.25 \times \text{area in square metres})}$$

The breadth in metres is given by area ÷ height.

Choice of Camber and Radius of Curvature

Camber is used to indicate the curvature of the main plate. It is usually given as the depth of the curve expressed as a percentage of the breadth of the otterboard (see Figure 1).

The camber also influences the hydrodynamic spreading efficiency. With a larger camber (ie curvature) the efficiency is greater but the otterboard will tend to be less stable. A camber of about 10% is usually considered to be a good compromise

With a camber of 10%, it may be useful to note that the inside radius (in mm) of the main plate will be given by:

$$1300 \times (\text{breadth in metres})$$

Choice of Height of Towing Plate(s)

The exact position of the towing plate is important. If it is exactly half way between the top and bottom edge then the trawlboard will fish nearly upright, with only a slight inward heel (top edge inwards). If the towing plate is positioned higher then the inward heel increases. This has the effect of lifting the gear higher in the water so that more warp is required to achieve a given depth. This is usually a disadvantage but it does allow a greater range of depth to be achieved by changing speed.

Very often Suberkrub otterboards are manufactured with two towing plates — one at half height and the other at a position 5% of the height above half height. The lower position is used to obtain maximum depth for a given warp length, whilst the upper position is used if a large variation with speed is required or if the net is to be fished close to the surface.

Choice of Position of Backstrop Attachments

For maximum stability the upper and lower backstrops are usually shackled to holes in the top plate and keel plate (see also sections on Top Plate and Keel Plate, pp. 9 & 10). Past designs have sometimes provided alternative backstrop attachment plates, eg above the keel plate, but small changes in backstrop position have no significant effect on performance when a single backstrop system is used.

Details of Manufacture

The aim of this section is to discuss some of the main points to be taken into account in specifying the individual components from which the board is manufactured (Figure 1).

Where possible, guidance has been given on dimensions and in particular on thickness of metal suitable for different sizes of board (Table I).

The design needs to be mechanically strong and hydrodynamically efficient. Often these requirements conflict and individual designers will put different emphasis on the two aspects. The following sections do not contain rules which must be followed but rather a means of prompting the designer to consider the issues involved.

Table I
The Principal Dimensions of Suberkrub Type Boards between 1.5 and 7 m^2

		Area from 1.5 to less than 2 square metres	Area from 2 to less than 4 square metres	Area from 4 to 7 square metres
MAIN PLATE:				
thickness	mm	5	5	6
inside radius	mm	1300 x (breadth in metres)		
TOWING PLATE (see Fig. 6):				
thickness	mm	6	6	12
dimension A (minimum)	mm	50	60	80
dimension B (minimum)	mm	60	80	100
dimension C	mm	30	40	60
TIE BARS:				
diameter	mm	25	25	30
pad thickness	mm	10	10	12
pad size	mm	100	100	120
BALLAST PLATE:				
thickness		see Table II		
height		35% of board height		
TOP PLATE:				
thickness	mm	10	12	12
KEEL PLATE:				
thickness	mm	30	40	50
REINFORCING ANGLES:				
thickness	mm	4	5	6
size	mm	50 x 50	75 x 75	90 x 90
BACKSTROP ATTACHMENT HOLES (see Fig. 7):				
dimension A	mm	45	60	60
dimension B (minimum)	mm	65	80	80
dimension C	mm	90	110	110
LIFTING RING (see Fig. 9):				
dimension A	mm	20	25	25
dimension B	mm	150	200	200
dimension C	mm	10	12	12
dimension D	mm	40	50	50
dimension E	mm	200	250	250

Main Plate

The mild steel plate is subjected during use to a complex three-dimensional stress system and it is one of the most critical areas of the board.

The main plate retains a residual bending strain caused by the rolling process during manufacture. Additional stresses are imposed by the main external loads. Because the sectional modulus is small around the X-X axis (Figure 4) it is most vulnerable to buckling about this axis.

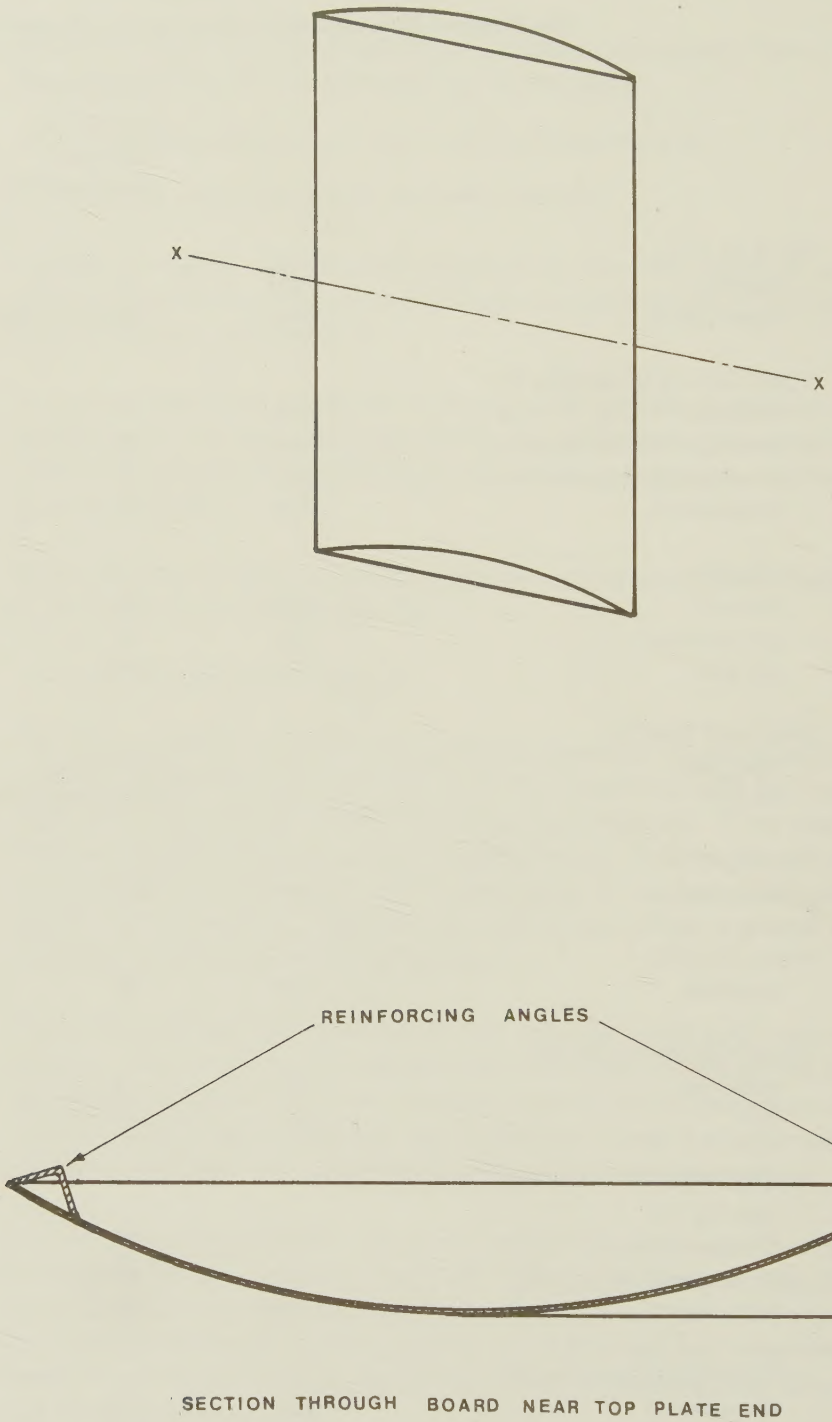


Figure 4 **Axis system used to describe the otterboard, and detail of leading and trailing edge reinforcing angles.**

It is advisable to use a minimum thickness of 5 mm to maintain reasonable over-all strength and to prevent buckling during welding.

Imperfections at regions under load can cause concentrations of stress of up to five or six times the normal. This suggests that as far as possible, it is desirable for the main plate to be constructed from one complete section, thus avoiding imperfections at welds. In two recent cases of board failure due to buckling, it was found that the main plate had been constructed from two half plates with a welded joint at the highly stressed central section. If the main plate has to be built from more than one section, it is advisable to restrict any seams to the lower region of the board where the buckling loads are less, and there is the added strength of the ballast plate.

Reinforcing sections along the inside of the leading and trailing edges of the main plate serve to stiffen it. Rolled steel angles appear to be the most effective sections from strength considerations (Figure 4). Hydrodynamically, semi-circular tube sections are more efficient than angles but their strength/weight ratio is much lower and they require extra work in manufacture. Suitable sizes of equal angle are given in Table 1.

Towing Plate

The towing plate is one of the most highly loaded components on the board; the most significant loading is tensile, there being little or no bending load. The plate is made from profile-cut mild steel and is continuously welded to the inside of the main plate. The profile of the towing plate is determined from the following dimensions:

1. The breadth of the board between the extremities of the curved main plate (also known as the chord length) (Figure 1).
2. The radius of curvature of the main plate.
3. The size of the reinforcing angles.

During manufacture these dimensions can be marked onto the steel plate from which the towing plate is to be cut, so that the relative positions of the main plate and strengthening angles can be established (Figure 5). The angled edges of the towing plate can then be marked out at angles of 35° and 8° as shown.

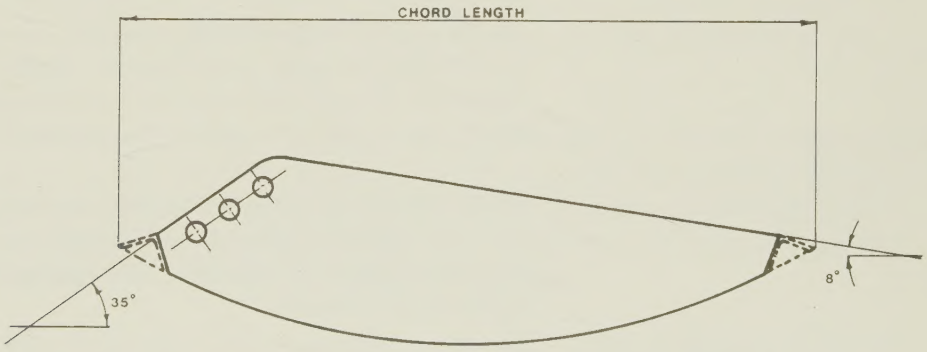


Figure 5 Illustration of profile of towing plate.

Two reinforcing plates are welded to each side of the towing plate (Figure 1). An elementary stress analysis suggests that the single plate without reinforcement would be sufficient to withstand the stress. The additional plates reduce wear and elongation of the towing holes caused by the harder material of the shackle pins. The extra plates also ensure correct alignment of the towing shackles, preventing them from slipping out of position and digging into the edges of the towing holes. The position of the three towing holes is to a large extent determined by the hydrodynamic towing requirements, and the size and type of shackle used. However, it is desirable to keep a certain minimum amount of metal between the holes themselves and

between the holes and the outside edge of the towing plate. Recommended distances and hole sizes are shown in Figure 6 and Table I.

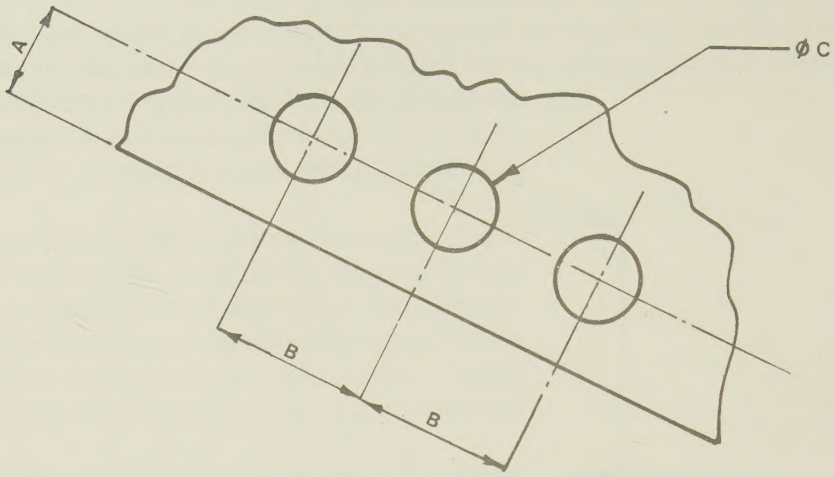


Figure 6 Dimensions and spacings for warp shackle holes in towing plate.

The towing plate should be joined along the whole length of the main plate to reduce the local tensile stress on the welds and the main plate. This region is already vulnerable due to the bending stresses caused by the external forces on the board.

Various methods of strengthening this critical central region around the towing plates have been tried while giving consideration to the hydrodynamic effects. The most effective of these appears to be the use of solid round tie bars, as shown in Figure 1, with the bars usually inclined at 45° to the towing plate. Certain points should be noted if this arrangement is adopted. The region where the solid bar is connected to the main plate should have a pad of metal between the bar and the plate to reduce the stress on the main plate at that point and to make welding easier. Furthermore, the bar ends should be cut at 45° to ensure strong welded joints.

Stress analysis suggests that two pairs of tie bars should be employed, one at the centre and the other near the towing holes. A further improvement would be the addition of solid tie bars between the towing brackets, if practical. Tie bar and pad sizes are given in Table I.

Some past designs have had rolled steel angles profiled and welded along the intersection of the main plate and the towing plate, but the minimal increase in strength obtained does not justify the increase in weight and the extra work involved.

Ballast Plate

To improve stability and to give the door added weight, a ballast plate made of rolled mild steel plate is continuously welded to the main plate and keel plate.

The centre of gravity of the whole board needs to be at about one third of the height of the board and it is convenient for the ballast plate to extend from the keel plate up to a height just beyond the centre of gravity. This allows the lifting ring to be attached to the ballast plate rather than to the weaker main plate.

Choosing the ballast plate height as 35% of the board height, the required thickness of the ballast plate is given for all sizes of door from 1.5 to 7 m^2 in Table II. Note that the reduction in thickness to 18 mm for boards over 4 m^2 relates to changes in other dimensions (see also Table I).

Table II

Recommended Ballast Plate Thickness for Suberkrub Boards from 1.5 to 7 m^2 (see also Table I)

Board Area (m^2)	Ballast Plate Thickness (mm)
1.50 to 2.24	10
2.25 to 2.49	12
2.50 to 2.74	14
2.75 to 2.99	16
3.00 to 3.24	18
3.25 to 3.49	20
3.50 to 3.74	22
3.75 to 3.99	24
4.00 to 4.24	18
4.25 to 4.49	20
4.50 to 4.74	22
4.75 to 5.24	24
5.25 to 5.49	26
5.50 to 5.99	28
6.00 to 6.24	30
6.25 to 6.49	32
6.50 to 7.00	34

Top Plate

The top plate is a profile-cut mild steel plate which is continuously welded to the main plate on both inside and outside curvatures. The radius of curvature of the top plate usually exceeds that of the outside surface of the main plate by approximately 6 mm to facilitate welding.

The suggested top plate thicknesses given in Table I are of adequate strength to withstand the impact loads occurring during hauling to the gallows or gantry of a stern trawler.

A recent development has been the combining of the top backstrop bracket and the top plate. The profile of the top plate has been enlarged to incorporate the backstrop attachment hole, and the metal thickness increased to accommodate backstrop loadings. These features appear to increase the strength of the board and simplify manufacture.

Strengthening rings are welded to each face of the top plate at the backstrop hole. They are usually the same thickness as the parent metal plate.

There is no particular set of rules governing the over-all size of backstrop section, other than to allow a sufficient distance between the hole and the main plate for a shackle to swivel. Recommended hole diameters and outside radii are given in Figure 7 and Table I.

Keel Plate

The keel plate, like the main and towing plates, is made from profile-cut steel plate. It is welded to the main and ballast plates at the bottom of the board, and is usually thick enough to provide additional weight in the lower half of the board. The perimeter of the keel plate is largely determined by the ballast plate curvature and thickness, ie it has to be large enough to

allow the ballast plate to be welded to it just inside its perimeter. Suitable thicknesses are given in Table I.

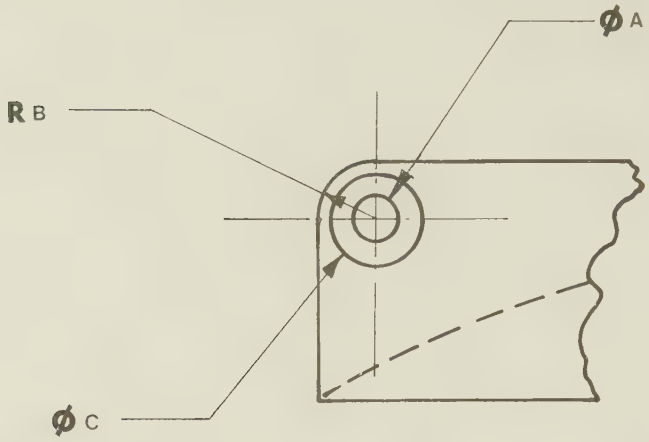


Figure 7 **Dimensions for backstrop shackle holes in top and keel plates.**

As in the case with the top plate, the bottom backstrop attachment hole can be incorporated in the keel plate to increase strength and simplify manufacture. This means that a larger shackle and consequently a larger hole are required to accommodate the greater thickness of the keel plate.

Backstrop Attachment Points

It is recommended that the top and bottom backstrop brackets are incorporated into the top and keel plates, respectively, to ease manufacture and increase strength (see Figure 8).

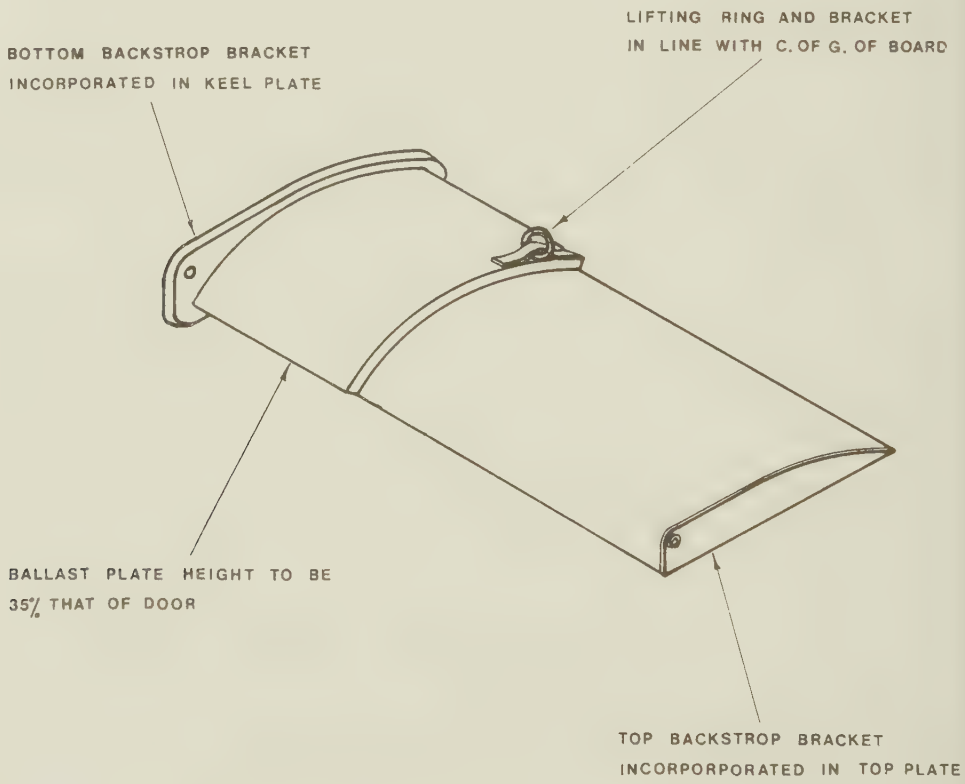

LIFTING RING AND BRACKET
IN LINE WITH C.OF G. OF BOARD
BOTTOM BACKSTROP BRACKET
INCORPORATED IN KEEL PLATE
BALLAST PLATE HEIGHT TO BE
35% THAT OF DOOR
TOP BACKSTROP BRACKET
INCORPORPORATED IN TOP PLATE

Figure 8 **Sketch of Suberkrub otterboard showing lifting ring and backstrop attachment holes.**

Lifting Ring and Centre of Gravity

The lifting ring is mainly for loading and unloading the board from fishing vessels in a convenient manner. The ring bracket is positioned on the leading edge (ie the towing side) of the board in line with the centre of gravity, so that the board is reasonably well balanced during lifting. It is normal practice for the centre of gravity to be about one third of the way up the board from the keel plate. Assuming that the size of ballast plate has been chosen as suggested in the section on Ballast Plate (p. 8), then the lifting ring should be attached at a convenient position close to the top of the ballast plate on the outside of the door near the leading edge. The arrangement of the ring bracket is shown in Figure 8. The ring itself is forged from mild steel round bar, and the bracket from bent mild steel flat bar which is welded to the main plate. The orientation of the bracket as shown in Figure 8 is probably the best, ie parallel to the X-X axis (Figure 4) of the door, because in cases where the bracket has been positioned at right angles to this, the ring has tended to dig into the main plate during lifting. Suggested ring and bracket sizes are shown in Figure 9 and Table I.

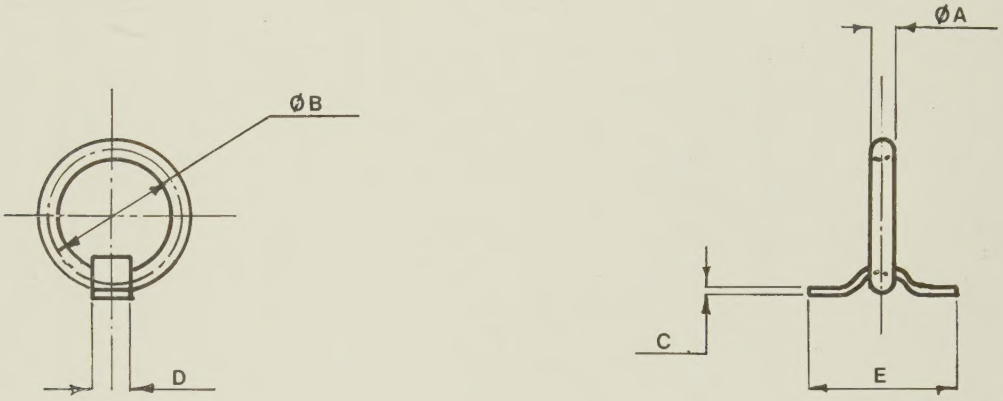


Figure 9 Dimensions for lifting ring and bracket.

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